Lecture 35, Apr 12, 2023

Motional EMFs

- We can think of it in 2 perspectives, either due to changing magnetic flux $V_{emf} = -\frac{\partial \Phi}{\partial t}$ or from a perspective of magnetic force $\vec{F}_m = q\vec{u} \times \vec{B}$
- Electrons in a moving conductor will have some velocity due to the movement of the conductor as a whole, so in the presence of a field they experience a force, causing an EMF
- This gives us $V_{emf} = \oint_C \frac{\vec{F}_m \cdot \mathrm{d}\vec{l}}{q} = \oint_C (\vec{u} \times \vec{B}) \cdot \mathrm{d}\vec{l}$
  - The $\vec{u}$ only exists on the moving parts of the conductor, so we can ignore any stationary parts
  - Note electrons have negative charge
- Application note: if we have a loop rotating in a uniform magnetic field, then $\vec{B} \cdot \mathrm{d}\vec{S}$ will vary as $\cos(\omega t)$, so we will produce a sinusoidal AC voltage
  - $V_{emf} = B_0 S\omega \sin(\omega t)$
  - Note the amplitude scales directly with frequency, and the output frequency is the same as the input frequency of the turning
  - What if we used an AC current to produce the field in the first place?
    * The EMF will now be the total EMF, a combination of both the transformer and motional EMFs
    * $V_{emf} = -N\frac{\partial \Phi}{\partial t} = -N\frac{\partial}{\partial t}\iint B_0 \sin(\omega t)\hat{a}_z \cdot \mathrm{d}\vec{s}$
    * The dot product introduces another cosine, so we end up integrating the product of a sine and cosine
    * This gives us a resulting voltage that varies with a frequency of $2\omega t$